Source Analysis for the NSFB Selenium TMDL

Technical Memorandum 2

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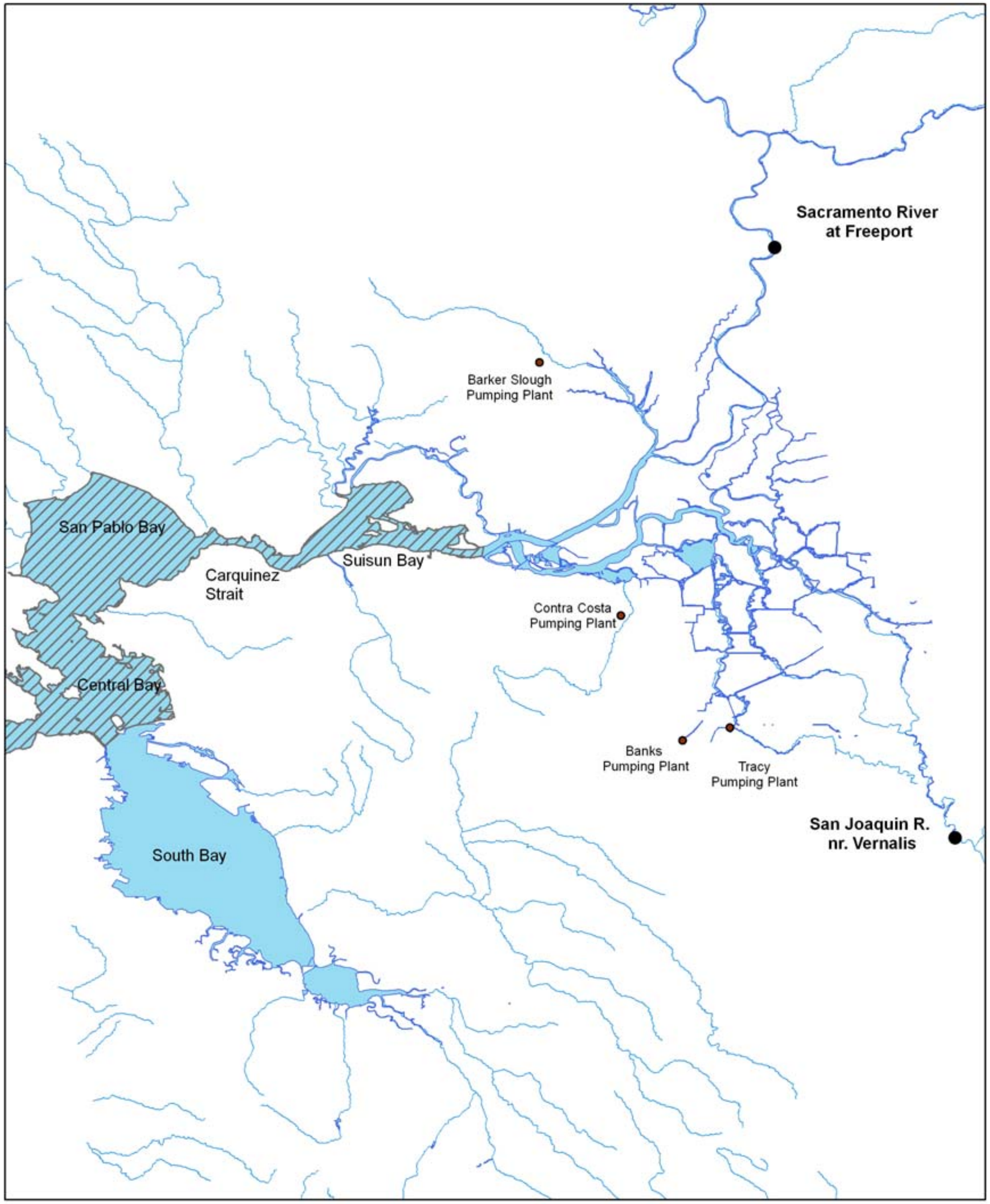
Presentation to

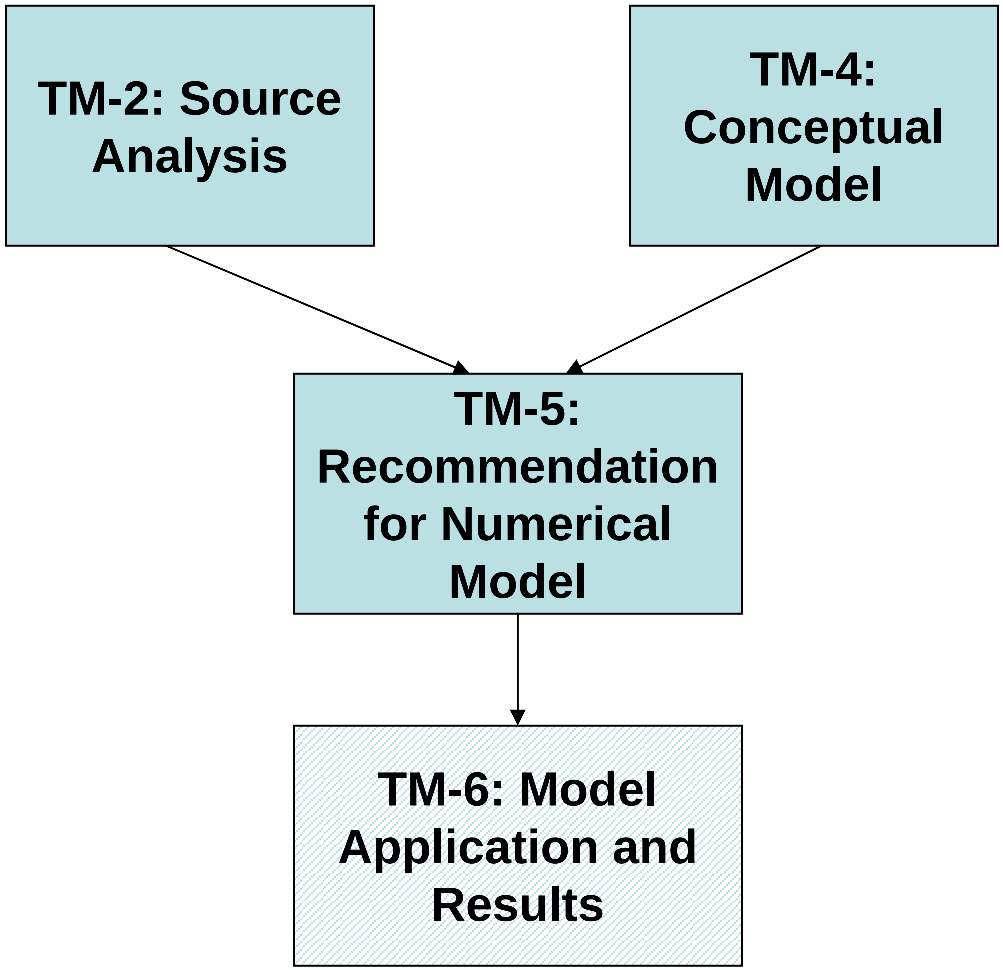
Advisory Committee

April 1, 2008

Geographic Scope of NSFB TMDL



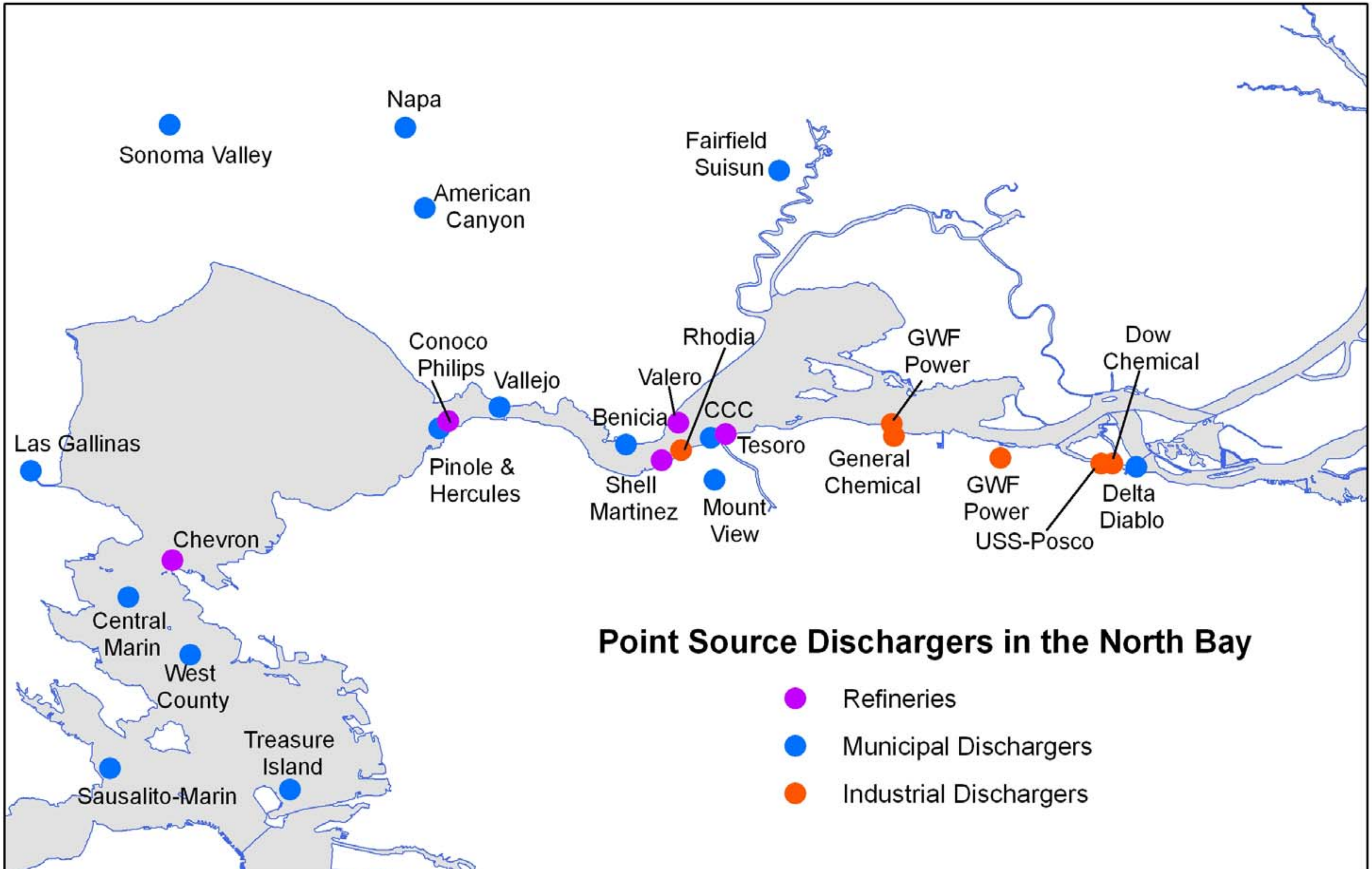
Technical Support Documents



Selenium Sources

- Point sources
  - Refineries
  - Other sources, primarily POTWs
- Delta Inflows
- Local tributaries
- Internal sediment sources
- Atmospheric deposition

Distribution of Point Sources



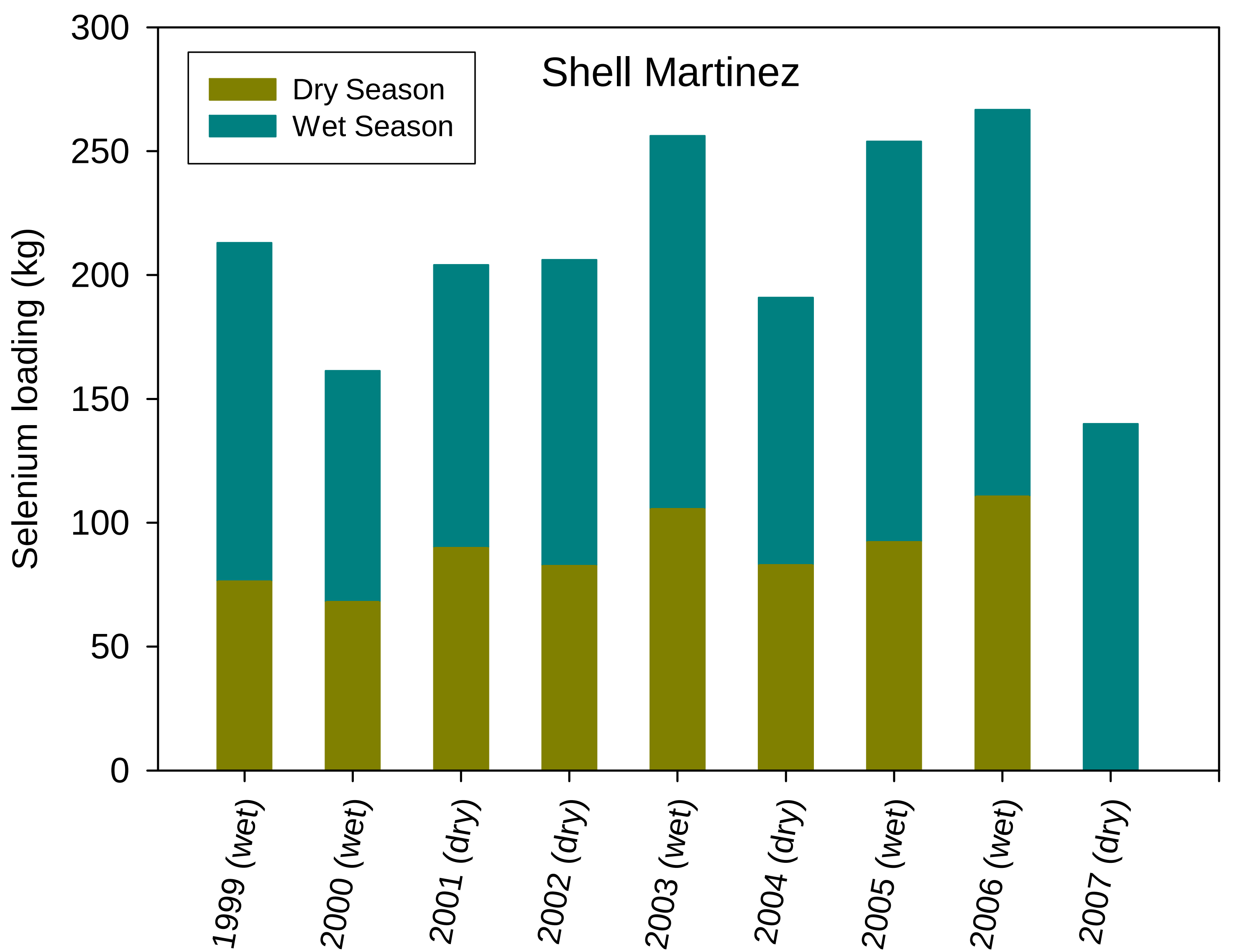
Point Source Loads

- All point sources in NSFB are well monitored with joint measurements of flow and selenium concentration
- Load calculation fairly straightforward: multiply flow and concentration
- No correlations between flow and concentration observed for any of the point sources

Refinery Load Estimates

Refinery	Flow (mgd)	Mean daily loading[1] (kg/day)	Mean daily loading (kg/day)	Annual loading[1] (kg/yr)
Chevron	7.1	0.31	0.33	112.6
Conoco Philips	2.3	0.16	0.16	57.9
Shell Martinez	5.8	0.61	0.59	224.1
Tesoro	4.1	0.19	0.19	70.2
Valero	2.0	0.20	0.20	71.9
Total	21.3	1.47	1.47	536.7

Refinery Load: Interannual Variation



POTW Sources

POTW Facility Name	Average flow (mgd)	Estimated Se Loadings[1] (kg/yr)	Estimated Se Loadings[2] (kg/yr)
City of American Canyon	0.9	2.1	1.5
City of Benicia	3.0	3.5	3.4
Central Contra Costa S.D.	74.6	21.8	15.0
Central Marin Sanitation A.G.	11.0	12.3	10.7
East Bay MUD	74.6	34.8	36.9
Fairfield Suisun Sewer Dist.	17.0	17.5	16.8
Las Gallinas Valley S.D.	3.5	3.3	4.0
Mount View S.D.	2.0	2.3	1.5
Napa S.D.	8.9	8.2	14.1
City of Petaluma	7.6	11.2	8.3
Cities of Pinole & Hercules	3.2	4.0	4.2
Rodeo S.D.	0.8	0.9	0.9
Sausalito-Marin City S.D.	1.6	2.3	4.9
Sonoma Valley County S.D.	7.4		High DL (5 µg/L) [3]
U.S. Navy Treasure Island	0.5	0.4	0.25
Vallejo Sanitation & Flood Control	13.2	19.7	16.7
West County Agency WCA	14.1	19.5	30.7
Total	**243.9**	**163.8**	**169.9**

Delta Loads

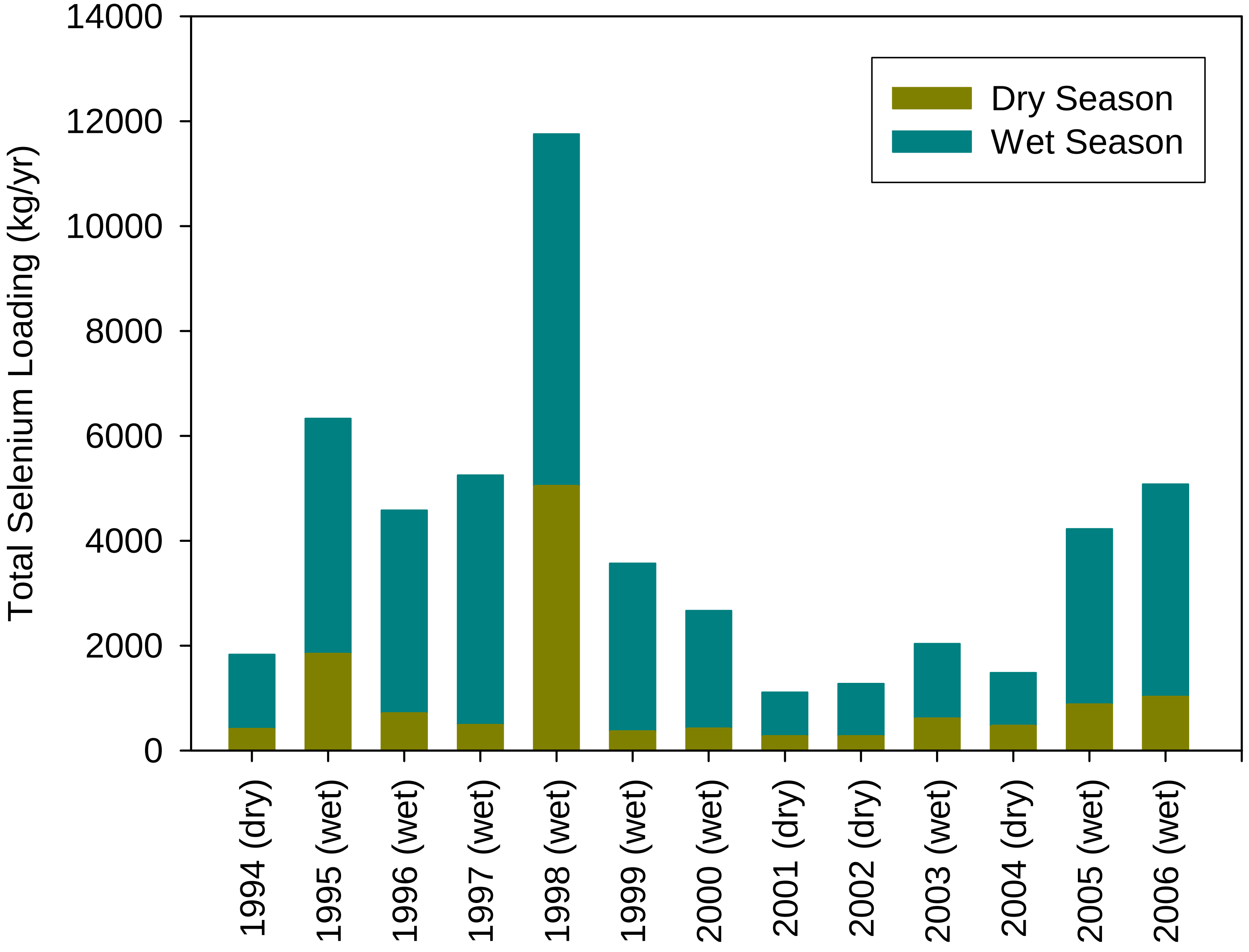
- Delta inflows are the most significant sources of freshwater and selenium into NSFB
- Concentrations in the two primary riverine inflows differ widely: San Joaquin about 6-10x greater than Sacramento River
- Delta exerts its own removal mechanism on influent selenium; in addition there are significant withdrawals in the four aqueducts
- At the bay/Delta interface, there is a strong tidal influence, especially when freshwater inflows are small

Delta Load Calculation

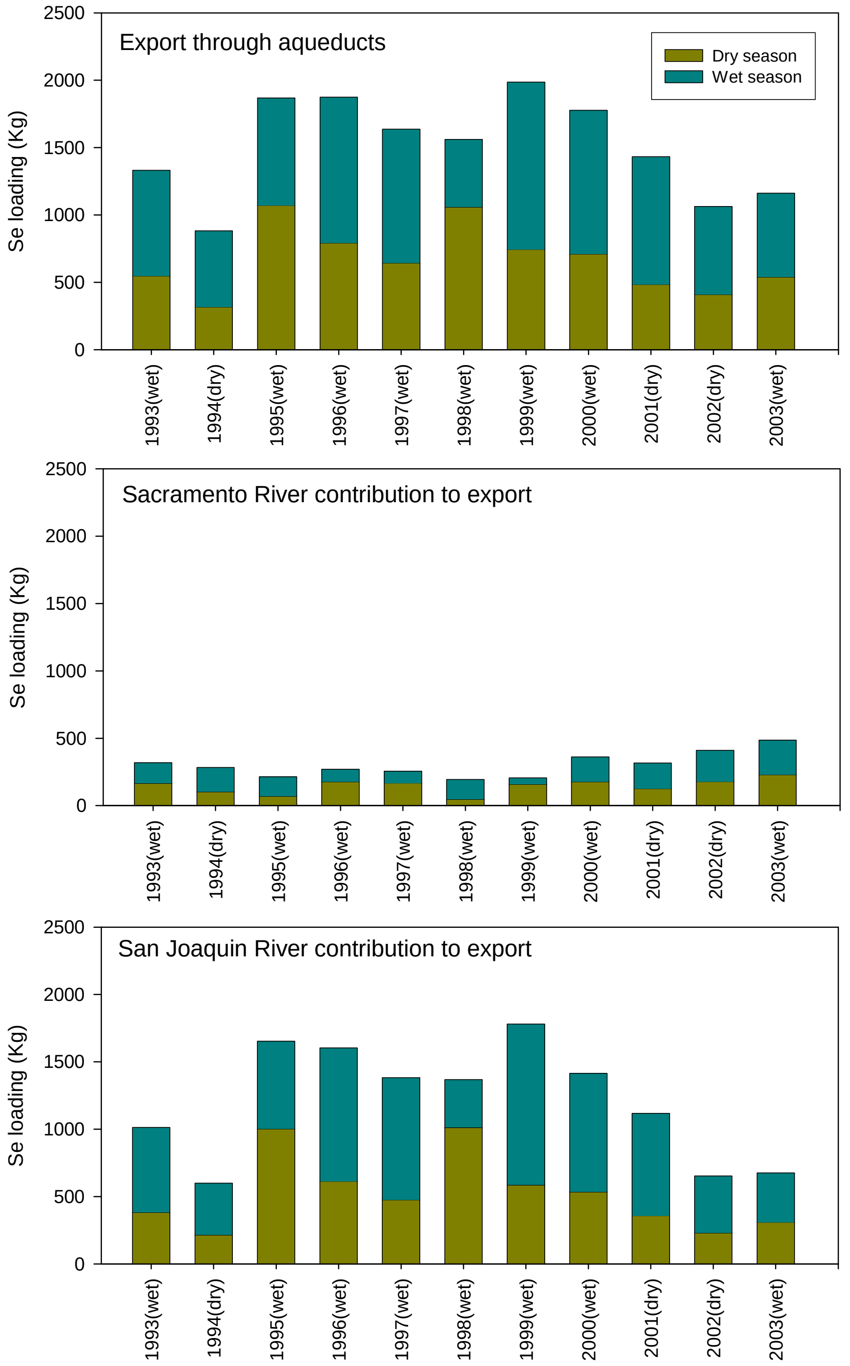
Three methods used:

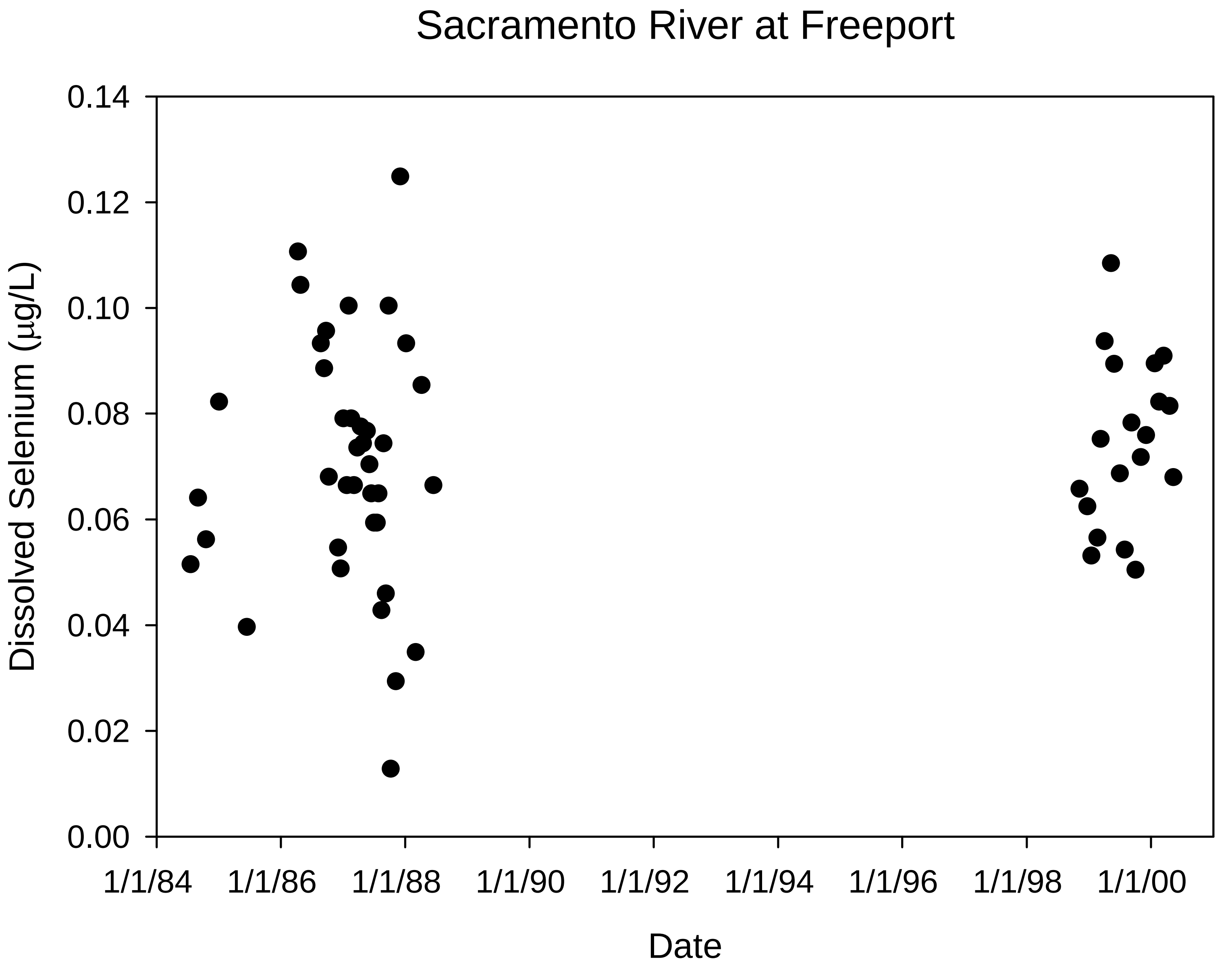
1. Concentrations at easternmost RMP stations multiplied by tidally corrected Delta outflows reported by DAYFLOW.
2. Add upstream loads from Sacramento and San Joaquin Rivers, with a fixed Delta removal constant
3. Add upstream loads from Sacramento and San Joaquin Rivers, and subtract actual estimates of loads through aqueducts

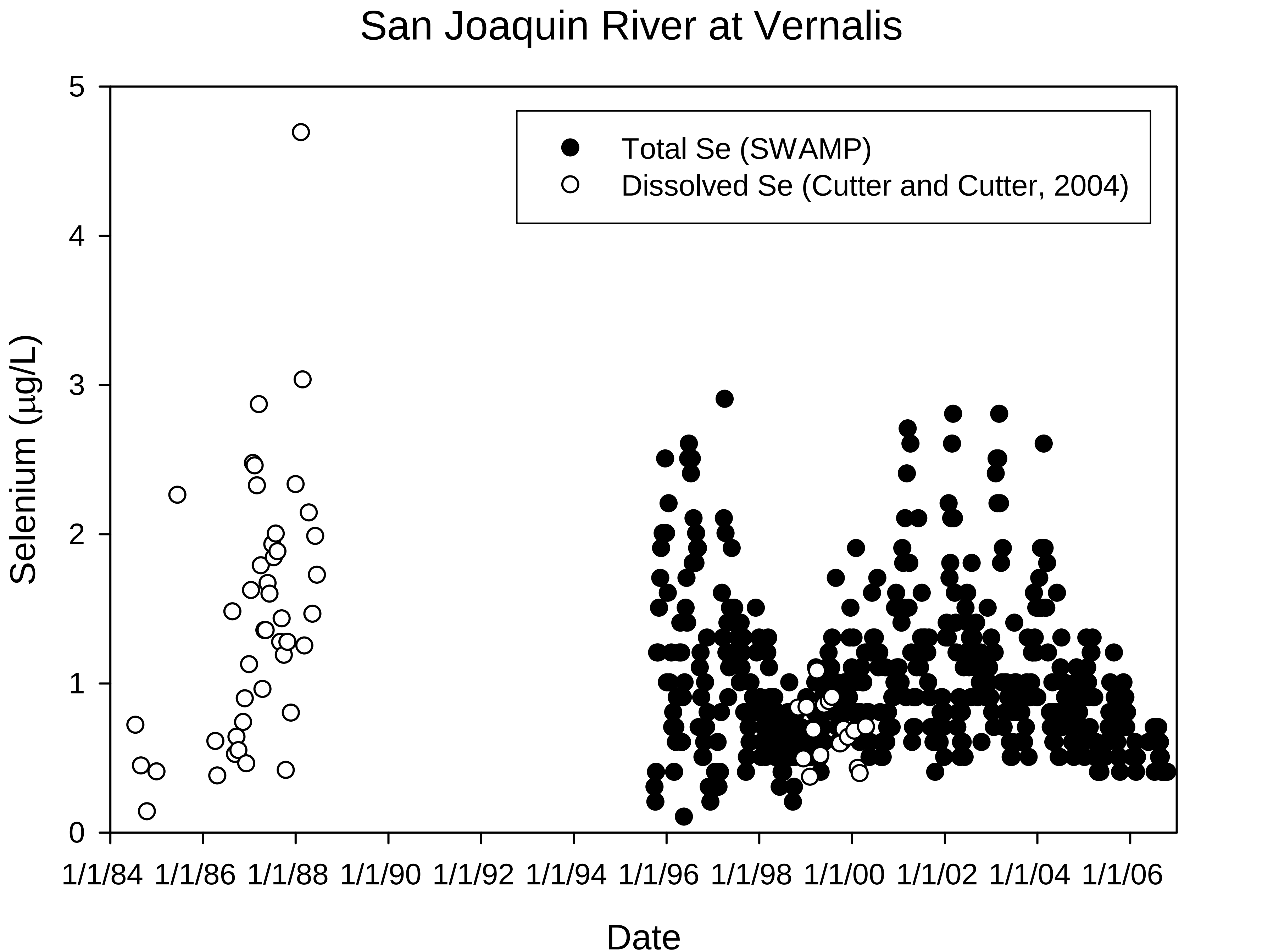
Delta Loads Interannual Variation
Method 1



Sacramento and San Joaquin Load Contributions




Sacramento River at Freeport
Dissolved Selenium (μg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1/1/84
1/1/86
1/1/88
1/1/90
1/1/92
1/1/94
1/1/96
1/1/98
1/1/00
Date

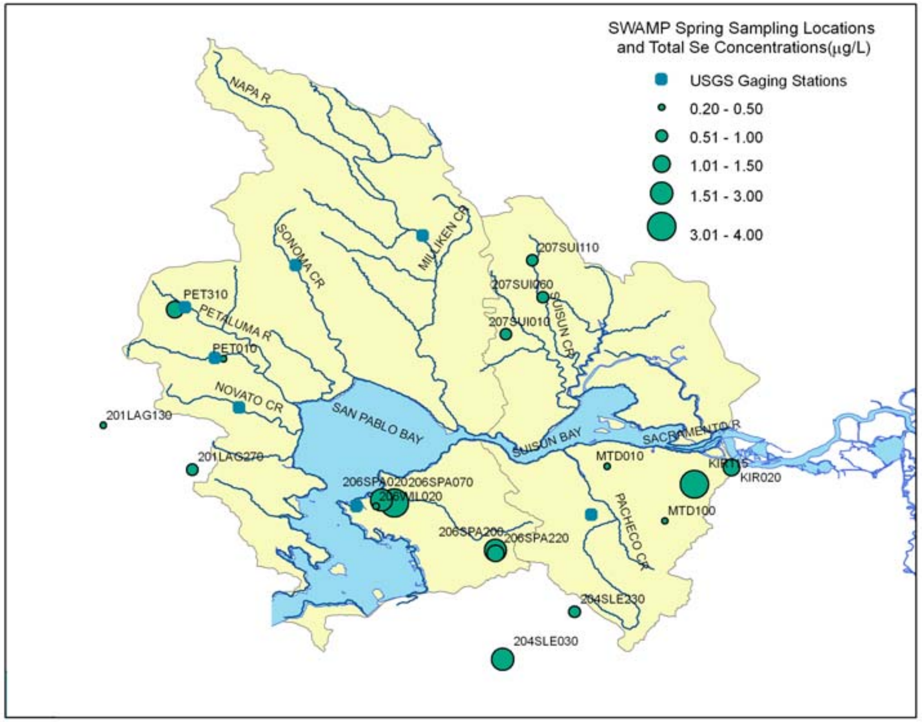

San Joaquin River at Vernalis
Total Se (SWAMP)
Dissolved Se (Cutter and Cutter, 2004)
Selenium (μg/L)
0
1
2
3
4
5
1/1/84
1/1/86
1/1/88
1/1/90
1/1/92
1/1/94
1/1/96
1/1/98
1/1/00
1/1/02
1/1/04
1/1/06
Date

Local Tributary Loads

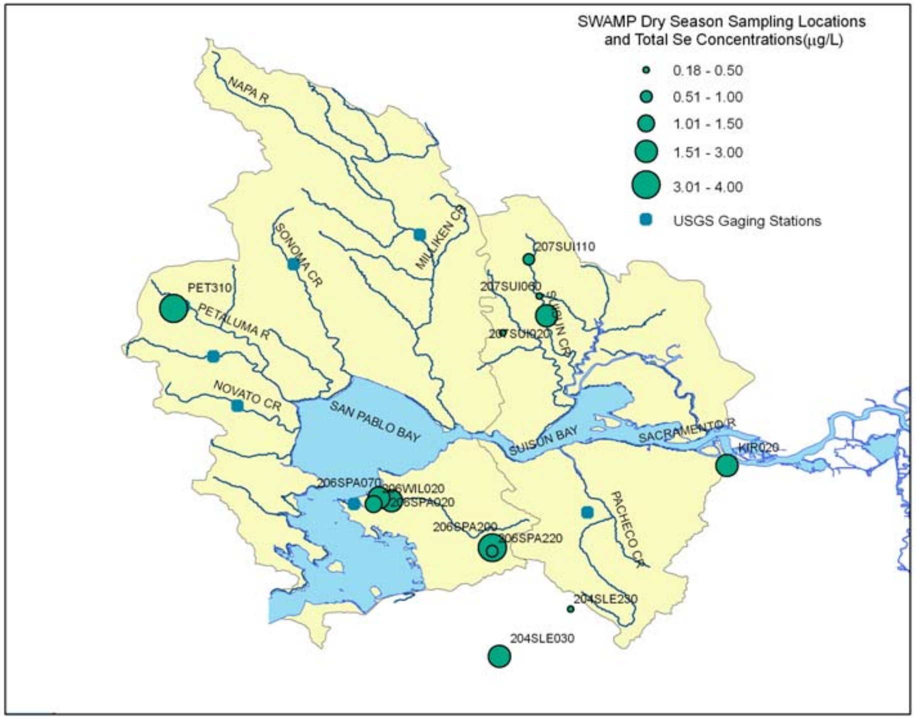
- Local tributaries can contribute selenium due to the presence of urban and agricultural lands in their watersheds.
- Selenium data are limited, although the existing SWAMP program suggests high concentrations
- Loads estimated as a product of concentration and flow, where flow is either scaled from a limited number of gauging stations, or estimated from a hydrologic model

Tributary Concentrations (SWAMP Data)

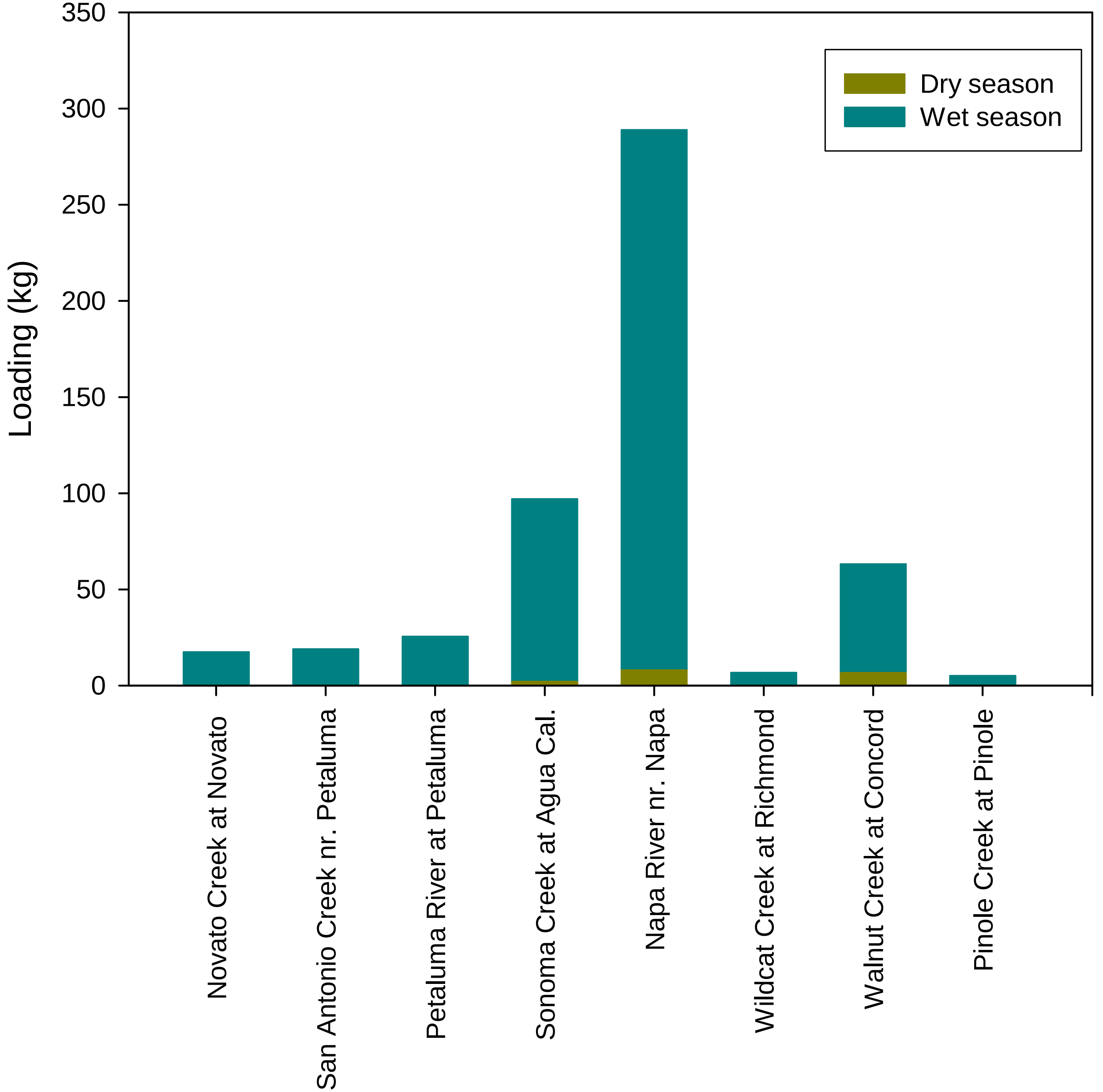
Spring



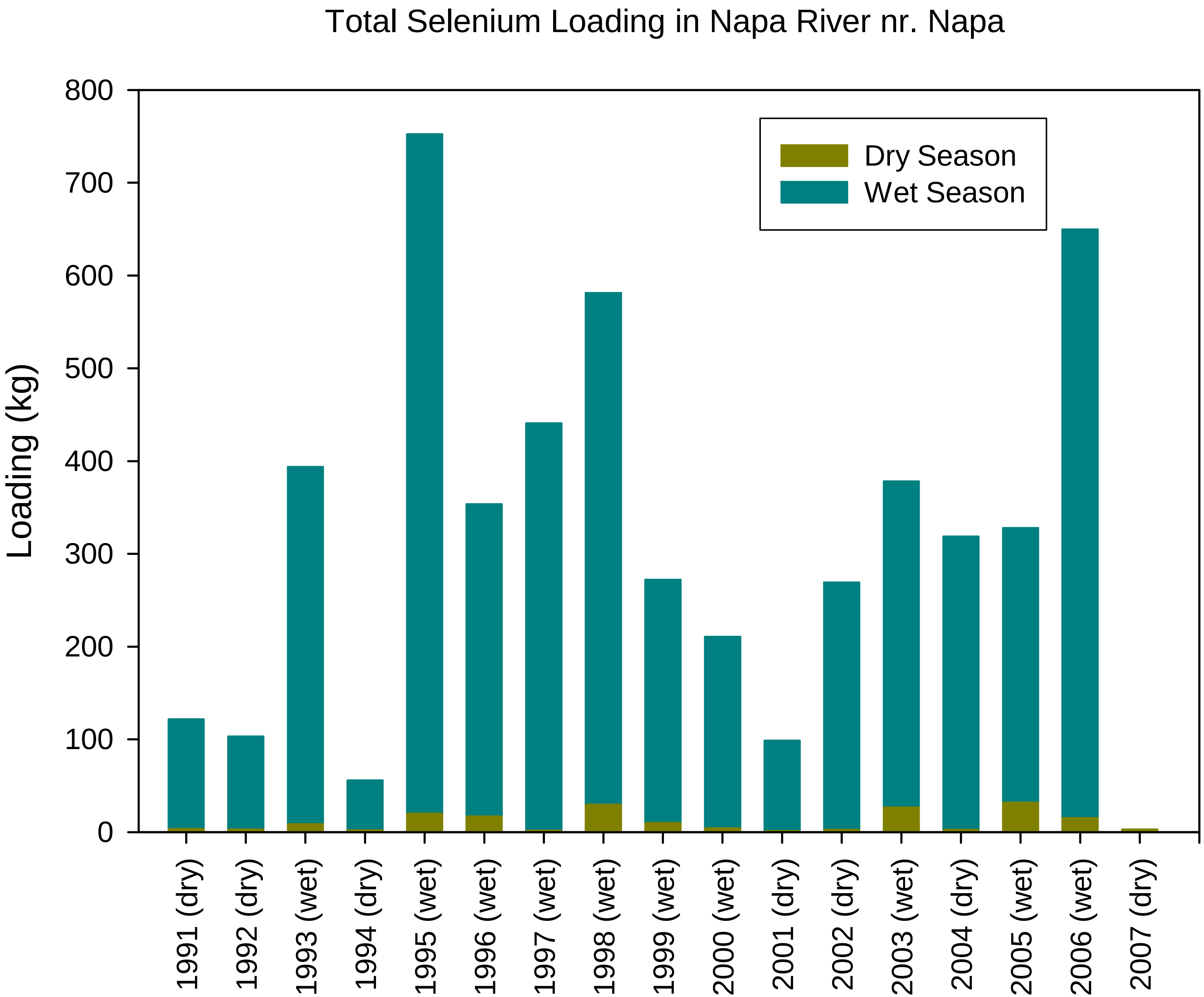
Wet



Estimated Loads (Wet and Dry Season)



Inter-Annual Variation



Internal Sediment Sources

- Based on sediment studies in San Pablo and Suisun Bay that suggest erosion in these areas in the recent years
- Sediment loss of Suisun and San Pablo Bay is estimated to be around 1,100 M kg/yr (SFBRWQCB, 2004)
- Average selenium concentration in surface sediment is at 0.25 µg/g. This results in selenium loadings due to sediment erosion of 275 kg/yr
- Diffusive flux is relatively small and is estimated to be 18 kg/yr
- Sediment dredging corresponds to a net loss of 82.5 kg/yr

Atmospheric Deposition

- No selenium data in rainfall, or estimates of dry deposition in NSFB
- Using data from the literature and limited regional data, we estimate concentrations in air and rain
- Direct wet deposition of selenium is in the range of 13.7 – 78.1 kg/yr (assuming rainwater selenium concentrations of 0.07-0.4 µg/L)
- Estimated dry deposition is in the range of 4.1 – 85.4 kg/yr based on air range of 0.3 – 2.4 ng/m^3 and deposition velocities of 0.1 cm/s and 0.26 cm/s

Relative Importance of Loadings from Different Sources

	Total (kg/yr)	Dissolved (kg/yr)	Particulate (kg/yr)	Uncertainty
Sources:				
Atmospheric deposition	17.8-163.5	13.7 – 78.1	4.1-85.4	High
Local tributaries	1,511	-	118.2[1]	High
Municipal and industrial wastewater	186	-	-	Low
Refineries	538	-	-	Low
Input from Delta	1,110-11,752 (mean:3,962)	814-9,736 (mean: 3,354)	151-1,509[2] (mean: 698)	Moderate
Sacramento River at Freeport		670-2,693 (mean: 1,577) for 1991-2007		Moderate
San Joaquin River at Vernalis	760-7,270[5] (mean: 2,972) for 1994-2007	838-4,711 (mean: 2,289) for 1991-2007		Moderate
Sediment	293	18.2[4]	275	Moderate
Sinks:				
Outflow	4500[3]	3750[3]	750[3]	Moderate
Sediment Dredging	82.5	82.5		Moderate

Key Findings

- **Selenium loads in NSFB are dominated by non-point sources, and therefore correlated with runoff. The non-point loads are highly variable both on a seasonal and annual basis.**
- **Local tributary selenium concentrations are high and result in significant loads to the NSFB, although more than 95% of this load is delivered in the wet months.**
- **Both San Joaquin and Sacramento Rivers are significant contributors of selenium to the NSFB. Their contributions are of similar magnitude and occur in both wet and dry seasons.**
- **The large Central Valley sources are transported through the Delta, and understanding of its role in the removal and/or export of selenium is based on a small amount of data.**
- **Point source loads (refineries, POTWs, and other industrial dischargers) are among the best characterized loads into NSFB because both flow and concentration are measured simultaneously.**
- **POTW loads are about a third of the refinery loads because of higher flow volumes.**